POPULATION STATUS AND HABITAT USE OF WILD PIGS *SUS SCROFA* IN KEOLADEO NATIONAL PARK, BHARATPUR, RAJASTHAN, INDIA

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The Indian wild pig population in Keoladeo National Park, Bharatpur was studied from January 2007 for six months. A total of 78 groups were sighted during the entire study period. Overall density was estimated to be 15.7 wild pigs / sq. km (%CV=17.99). The present density estimates were seven times that reported by Haque in 1990. Pellet group density was found to be significantly different ($F = 6.894$, $df = 5$, $P < 0.001$) among all the habitats, with the highest in short grassland open area (522 pellet groups / ha) and least in tall grassland savannah (20 pellet groups / ha). Male to female ratio was calculated to be 1:1.01 which was in coherence with the studies conducted elsewhere. Absence of predation pressure was attributed to be one of the key factors in determining the sex ratio at the time of maturity. Female to young ratio was 1:2.85, which represents a normally growing population of Wild pig in the Park. Mean group size exhibited by the population was (3.79 ±0.44). Larger groups were found in habitats with abundant food supply, whereas smaller group were in poor forage sites. Short grassland open area and mixed habitat were used much more in proportion to their availability, and tall grassland savannah and *Prosopis juliflora* thickets were used less than the availability. Grass density, quality forage, dense cover and easily accessible water source were suggested to be the dominant factors in determining the habitat utilization patterns of the Wild pig population in Keoladeo National Park.

Key words: Density, forage sites, groups, habitat utilization, Keoladeo National Park, predation pressure, quality forage, Wild pig

INTRODUCTION

The Indian Wild pig *Sus scrofa* is one of the most widely distributed mammals in the world, with its native range extending from Western Europe to south-east Asia (Bratton 1975; Massei and Genov 2004; DEFRA 2005). In recent decades, their number has increased worldwide (Morini *et al.* 1995; Baubet *et al.* 2004). The absence of predation pressure can be attributed as one of the major causes for successful spread of the species worldwide (Genov 1981; Saez-Royuela and Telleria 1986). It is very active as an opportunistic feeder and its diet varies among different habitats and geographical distributions, which surely contribute to the widespread distribution of the species (Ashby and Santiapillai 1998; Baubet *et al.* 2004; Massei and Genov 2004). Wild pigs are known to have a substantial environmental impact and affect many ecosystem components, being a key species in the trophic chain (Galvano-Alves 2004; Massei and Genov 2004). However, more importantly, their populations are known to damage crops and vegetation (Lacki and Lancia 1983; Scarcelli *et al.* 2004). Consequently, their populations are under pressure predominantly due to human-animal conflict, which needs to be controlled in a way that both management and conservation may go hand in hand and their survival may not be threatened in future. But before doing this, the management authorities should have some baseline data, such as population size, predation pressure, and habitat use on the species. Also, equally important is an investigation of various factors governing its distribution.

Till date, several studies have been conducted on ungulate species in the study area and throughout the country. Wild pig populations have, however, faced a continuous negligence for some reason. The role of Wild pigs in the ecosystem of Keoladeo National Park is not known; hence, we decided to carry out the studies pertaining to its population dynamics, composition, and habitat utilization patterns.

STUDY AREA

The study was conducted from January 2007 for a period of six months in Keoladeo National Park, Bharatpur. This 29 sq. km Park falls in the semi-arid biogeographical zone (Rodgers and Panwar 1988). It is a Ramsar Site, World Heritage Site, and Important Bird Area. The average elevation of the Park (Fig. 1) is about 174 m above sea level. Topographically, it is more or less flat with a gentle slope towards the centre forming a depression, total wetland area being about 8.5 sq. km. The Park is characterized by a sub-tropical climate with rainfall ranging from 283.7-481 mm. The summer temperature in the area ranges from 20.8-41.6 °C.

The vegetation of the area is a mixture of xerophytic and semi-xerophytic species. The classification of distinct

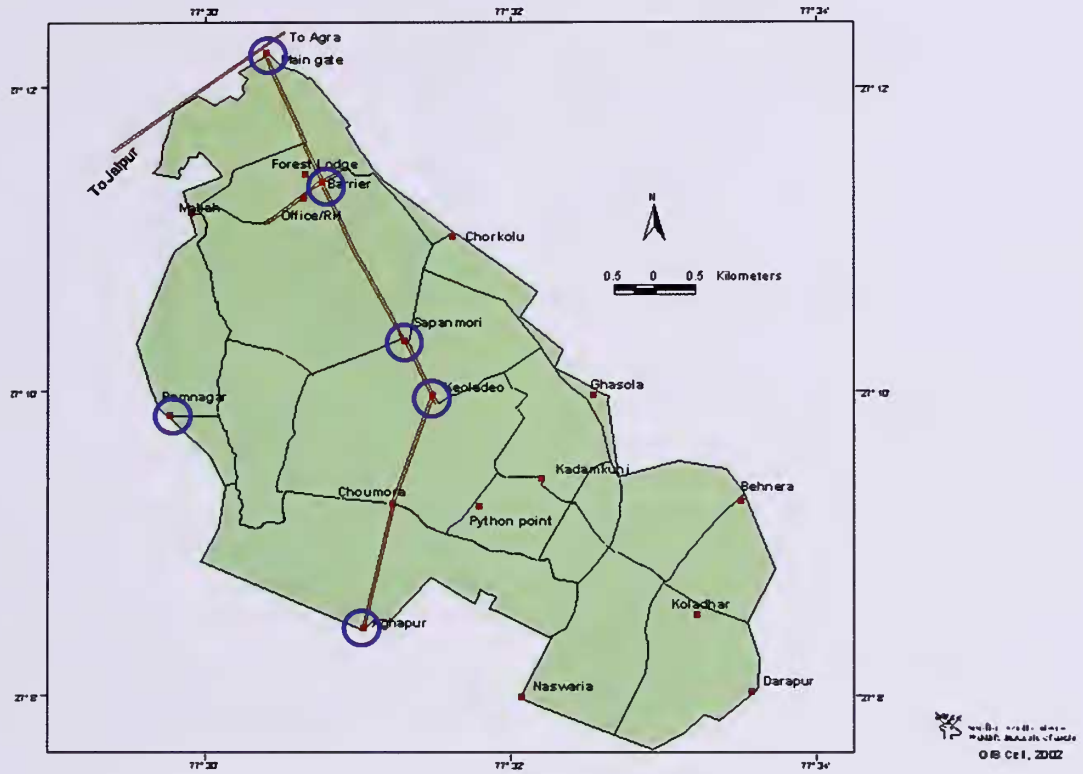

Fig. 1: Study area: Keoladeo National Park, Rajasthan

habitat types is quite difficult owing to the widespread distribution of *Prosopis juliflora* in the entire Park area. However, based on the present study, the general floral composition of the study area is characterized as: (1) **Wetland** with aquatic vegetation mainly consisting of emergent, rooted floating, submerged and free floating plant species (Vijayan 1987). (2) **Woodland** with *Mitragyna parvifolia*, *Acacia nilotica*, *Zizyphus mauritiana* and *Syzygium cumini* as the dominant species and a dense shrub storey comprising mainly of *Prosopis juliflora*. (3) **Mixed habitat** consists of irregular distribution of trees diffused with thorny shrubs in the undergrown layer. The ground is covered with short grass species like *Cyperus rotandus* and *Sporobolus* spp. (4) **Dried Wetland** resulting from water scarcity in the Park has *Paspalum disticum*, *Parspaladium* spp. and *Cyanodon dactylon* as dominant grass species and exhibits maximum number of herbs, i.e., *Amaranthus viridis*, *Euphorbia aubiculata*, *Melilotus indica*, (5) **Grassland** of three types: (a) Tall grassland having *Vetiveria zizanioides* and *Desmostachya bipinnata* as the dominant species. (b) Savannah, with scattered distribution of some trees. (c) Short grassland having continuous layer of short grasses, such as *Cyanodon dactylon* (6) *Prosopis juliflora* dominated area in the Park is about 15-17 sq. km. It consists of dense to discontinuous thickets of *Prosopis juliflora*.

METHODOLOGY

The Wild pig density and its distribution in Keoladeo National Park were studied using two methods. Line transect method (Burnham *et al.* 1980) was used to estimate the overall density in the study area and pellet group count method was used to calculate the density in each habitat separately. Indirect evidences were used for habitat-wise density estimation as direct sightings in some habitats were less than forty, thus not fulfilling the assumptions for the software DISTANCE. In all, six transects, one laid in each habitat based on reconnaissance surveys, were monitored twice a day during 0600 to 0900 hrs and 1700 to 1900 hrs. The Wild pig being shy, the activity could not be recorded on trails, hence transects were laid passing through the interior of the blocks. Transects were surveyed carefully in order to avoid sudden disturbances. Frequent pauses were made to listen for sounds of Wild pig during the transect surveys.

To study the habitat features, circular plots of 10 m radius were laid in each habitat and the habitat characteristics were then correlated with the Wild pig density. Plots were laid 50 m away on either side of transect to avoid sampling of disturbed vegetation. Within the 10 m radius plots, circular plots of 3 m radius were also laid for pellet counts to estimate the habitat-wise density. A total of 280 vegetation plots were

laid in different habitat types of the study site with an average of 40-44 plots in each habitat.

Data was analyzed using DISTANCE version 5.0 beta 5 (Thomas *et al.* in press). The model half-normal was selected as the most appropriate model for estimating density on the basis of minimum AIC value. Density, encounter rate, effective strip width and mean group size were derived using the software. Pellet group density in each habitat was calculated and tested for significant differences in their mean by using one-way ANOVA. Species density for each habitat was calculated using appropriate formula. Species diversity and richness were calculated using Shannon-Wiener Species Diversity Index (H') and Margelef's Index (RI) respectively by SPECDIVER; a DOS-based modified module of STATISTICAL ECOLOGY. To assess the habitat utilization patterns of Wild pig, the statistical program PREFER was used (Gupta and Prasad 1992), and the preferences and avoidances for each habitat were examined by means of Bonferroni z-intervals and confidence intervals (Neu *et al.* 1974; Byers *et al.* 1984). To assess the difference in habitat utilization of Wild pig in different months of the study period, Habitat Preference Index (HPI) (Aspinall *et al.* 1998) was calculated based on the encounters in a particular habitat in different months. To extract the correlation among different habitat variables and Wild pig pellet group densities Pearson's Product Moment Correlation Coefficient was performed.

RESULTS

Density

The overall density of Wild pigs in Keoladeo National Park (KNP) was found out to be 15.7 Wild pig / sq. km (%CV= 17.99). The effective strip width was 61.33 ±4.8 m (%CV=17.99). Mean pellet group density of Wild pig was highest in short grassland open area 522 pellet groups / ha, followed by mixed habitat 307 / ha, dry wetland 230 / ha, *Prosopis* thickets 40 / ha, and tall grassland Savannah 20 / ha. Pellet group density varied significantly across different habitats ($F = 6.894$, $df = 5$, $P < 0.001$).

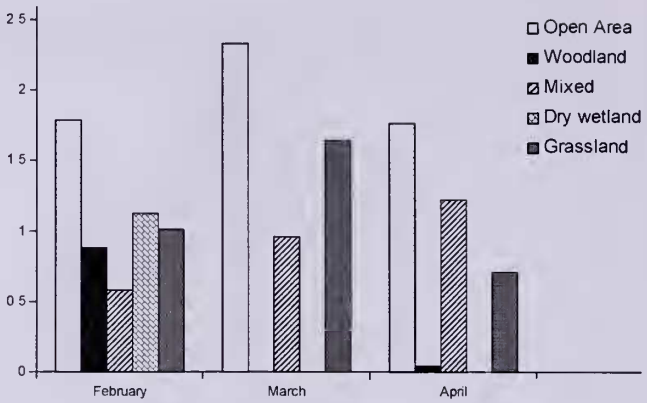

Fig. 2: Habitat Preference Index (HPI) of Wild Pig in different habitats in KNP

Population composition

Out of the total 293 individuals sighted, which includes all the replicate sightings of wild pigs during all the monitorings repeated for all the transects, 14% were adult boars (males), 15% were adult sows (females), 18% were subadult boars, 3% subadult sows and 39% were young ones. 11% of the population remained unsexed. The adult male to female ratio was 1:1.01, subadult male to female ratio was 6:1, while female to young ratio was calculated to be 1:2.85.

Table 1: Results of habitat preference or avoidance (using PREFER Software) by Wild Pig in Keoladeo National Park

Habitat	Total Area (sq. km)	Observed Use	Expected Proportion Use (Pi)	Bonferonni intervals
SGOA	4.405	157	0.152	*** 0.289>(*Pi*)<0.407
Woodland	1.678	42	0.058	** 0.057<(*Pi*)<0.129
Mixed	5.203	168	0.18	*** 0.312>(*Pi*)<0.433
Dry Wetland	4.196	52	0.145	** 0.076<(*Pi*)<0.155
Tall Grassland Savannah	6.084	17	0.21	* 0.014<(*Pi*)>0.061
Prosopis juliflora Thickets	7.343	15	0.254	* 0.011<(*Pi*)>0.056

* Avoided
** Used in relation to availability
*** Preferred
Values in parenthesis represent the Bonferroni Confidence Intervals
SGOA; Short Grassland Open Area

Group size

During all the replicate monitorings of all the six transects laid in the entire study period, 78 groups of Wild pigs were detected with a mean cluster size of 3.79 ±0.44, where the mean group size in short grassland open area was estimated to be 4.5, in woodland it was 2.0, in mixed habitat 4.2, for dry wetland 5.25, and 2.0 for tall grassland savannah. Rooting was the most frequent activity (41%) exhibited by the larger groups of wild pigs.

Habitat use

The utilization of short grassland open area habitat and mixed habitat was found to be more in proportion to their availability. Woodland and dry wetland were used in accordance with the availability, whereas tall grassland savannah and *Prosopis juliflora* thickets were avoided (Table 1).

Correlation analysis for pellet group density of wild pig and different habitat variables exhibited a significantly positive relationship with grass density ($P < 0.05$), shrub cover ($P < 0.05$), chital density ($P < 0.05$), blue-bull density ($P < 0.05$), hare density ($P < 0.01$) and jackal density ($P < 0.05$), while a significantly negative correlation was seen with canopy cover ($P < 0.05$), tree height ($P < 0.05$), GBH, i.e., girth at breast height ($P < 0.01$), bare ground ($P < 0.01$) and distance from water source ($P < 0.01$) (Table 2).

Table 2: Pearson's product moment correlation between pellet group densities of Wild Boar in different habitats with different habitat variables in Keoladeo National Park

S.No.	Habitat Variables	Pearson's coefficient correlation value with Wild pig pellet group densities
1	Tree Cover	- 0.098
2	Canopy Cover	- 0.126*
3	Tree Height	- 0.155*
4	GBH	- 0.190**
5	Tree Density	- 0.104
6	Tree Diversity	- 0.111
7	Tree Richness	- 0.107
8	Shrub Cover	0.265*
9	Shrub Height	0.169
10	Shrub Density	0.073
11	Shrub Diversity	0.039
12	Shrub Richness	0.120
13	Grass Height	0.089
14	Grass Density	0.142*
15	Grass Diversity	0.119
16	Grass Richness	0.050
17	Litter Cover	0.037
18	Bare Ground	- 0.261**
19	Grass Cover	0.089
20	Herb Cover	0.083
21	Chital Density	0.143*
22	Nilgai Density	0.134*
23	Cattle Density	0.017
24	Hare Density	0.317
25	Jackal Density	0.122*
26	Distance from water source	- 0.284**

Significance level
**= 0.01
*= 0.05

Table 3: Habitat Preference Index (HPI) for Wild Pig in different habitat types

Month	Short grassland Open Area	Woodland	Mixed	Dry wetland	Tall Grassland Savannah
February	1.790	0.88	0.58	1.126	1.01
March	2.332	0	0.96	0	1.644
April	1.765	0.042	1.224	0	0.711

Habitat preference index (HPI) (Allen 1983) was highest for short grassland open area for the three months (February, March and April). In February dry wetland, in March tall grassland and in April mixed habitat was preferred after low grassland open area (Table 3; Fig. 2).

DISCUSSION

Density

The estimated density of wild pig population, i.e., 15.7 individuals / sq. km in the study area suggests a consistent growth pattern as it is seven times that reported by Haque in 1990 (2.24 individuals / sq. km), though the study was for a period of three years and was not specifically focused on wild pigs. The growth exhibited by the population could primarily be attributed to the absence of predation pressure in KNP, as is the case exhibited worldwide (Genov 1981; Saez-Royuela and Tellaria 1986). Wild pigs are capable of rapid population increases due to early onset of puberty, their ability to have large litters and potential to breed more than once per year (Baber and Coblentz 1987). They are also known to have the highest reproductive rate among ungulates (Massei and Genov 2004). Moreover, being an opportunistic feeder, a generalist and an adaptable omnivore, Wild pigs are capable of altering and adjusting its diet in accordance to the availability in the surrounding environment (Henry and

Table 4: Growth trends in ungulate population during the last few years in Keoladeo National Park

Species	Density (sq. km) (Haque, 1990)	Density (sq. km) (Present study, 2007)
Wild Pig	2.24	15.73
Chital	9.79	86.9
Nilgai	7.0	16.8
Sambar	0.75	0.54

Conley 1972; Massei and Genov 2004). High fecundity and early onset of maturation are other factors contributing to an astonishing growth in the wild pig population (Coblentz and Bouska 2004). Increase in the species' population in the countries overseas, during the last few decades has also been attributed to socio-economic changes. Socio-economic changes are known to result in improved environmental conditions for the species, variations in the dominant crop types, limited hunting, additional food and climatic conditions (Genov 1981; Erkinaro *et al.* 1982; Saez-Royuela and Telleria 1986).

On considering the growth trends of other ungulate species in Keoladeo National Park (KNP), during the last two decades, a positive interaction appears between the Wild pig population and other ungulate species (Table 4). Interspecific competition seems to play no inhibitory role in the growth of Wild pig population inhabiting the Park. Also, in the absence of natural predators boar numbers are limited only by the availability of resources (such as food and shelter), or by human intervention (DEFRA 2005). Thus, the rapid growth exhibited by the population is not very surprising.

The highest mean pellet group density in short grassland open area may be due to several factors, including quality forage, easy access to water source and dense thickets to hide and seek shelter (Kearney and Gilbert 1976). High density in mixed habitat may also be due to abundant food supply, water accessibility, high cover and least disturbance, whereas low densities in *Prosopis juliflora* thickets and tall grassland savannah can primarily be attributed to unavailability of food.

Population composition

The estimated male to female ratio of wild pig population in Keoladeo National Park (1:1.01) is similar to that of Pakistan (1:0.75) (Ahmad *et al.* 1995), Jaldapara (1:1) (Schaller 1967) and Lithuania (1:1.04) (Janulaitis 2003). But, the observed trend goes against the normal female biased sex ratio, exhibited among all animals in general, the males being more prone to predation and environmental stress. The equal male to female ratio from birth to maturity amongst Wild pigs could primarily be attributed to the absence of a natural predator. The female to young ratio in a stable population of most of the mammals is approximately 2:1 (Smith 1990), whereas in this study it is 1:2.85, which represents more number of young, thus indicating a normally growing population (Smith 1990).

Group size

The mean group size of the Wild pig population in the present study (3.79) was within the range reported at other places and was very close to the most frequent group size (4) exhibited by European populations (Bon *et al.* 1986). Mean group size for Iberian populations is generally 3-5 individuals (Rosell *et al.* 2001) and a group size of 4.4, 4.3 and 3.2 individuals per group have also been reported in other populations (Merino and Carpinetti 2003; Rosell *et al.* 2004). Larger groups were detected in short grassland open area, dry wetland and mixed habitat, whereas smaller groups were seen in woodland and tall grassland savannah. Mainly two factors are known to affect the grouping behaviour of the ungulates, first to avoid predation (Hamilton 1971), and the second relates to the distribution and availability of food supply (Altman 1952). However, in the absence of predation pressure in the area, food availability seems to govern the group size of the Wild Pig population.

Habitat use

The short grassland open area was used more than was available. Food availability, shelter, thermal comfort, safety, quietness, weather conditions and human disturbance acted as significant determinants in habitat selection by Wild pigs (Kurz and Marchinton 1972; Kearney and Gilbert 1976; Singer *et al.* 1981; Meriggi and Sacchi 1992; Boitani *et al.* 1994; McCann *et al.* 2003). Deciduous woodlands generally provide the most appropriate habitat for Wild pigs (Leaper *et al.* 1999). But human intervention and disturbance affect Wild pig presence (D'Andrea *et al.* 1995; Maillard and Fournier 1995; DEFRA 2005); therefore the woodland habitat in KNP, experiencing the maximum disturbance being located near the boundary, is less preferred. Wild pigs are known to use open habitats, such as heathland and grassland. Although these offer little shelter, they do provide alternative food resources (Leaper *et al.* 1999). Wild pigs are generalist and are well-known to alter their diets according to availability (Coblentz and Baber 1987; Schley and Roper 2003; Massei *et al.* 1996). They alternatively consume plant species associated with grassy heathland habitats, for example, broad-leaved grasses and roots of certain species (Groot *et al.* 1994). Hence, these habitats are important to wild pig, though being suboptimal (Leaper *et al.* 1999). Also, this habitat exhibited the maximum Habitat Preference Index (HPI) during the entire study period. The late sightings of Wild pigs in open area on warm winter mornings and early sightings in cool pleasant summer mornings go in accordance with the fact that the animal is active when difference between body temperature and atmospheric temperature is minimum (Haque 1990). Therefore, ungulates are in open during the warmer parts of the day in winter and tolerable parts of the day during summer to escape heat (Haque 1990).

The mixed habitat was preferred next to the short grassland open area. Wild pigs are generally found to live in mixed

forest stands and meadows, and do not leave their home ranges until extensively disturbed (Polmeyer and Sodiekat 2003). High HPI for mixed habitat next to short grassland in April can be because Wild pigs, lacking sweat glands as a physiological means of thermoregulation, employ behavioural mechanisms to regulate body temperature (Coblentz and Baber 1987). The presence of dense shrub cover of *Salvadora persica* and *Capparis separia* provide cool resting places for Wild pigs. Haque (1990) also confirmed the preference of shrub layer mostly in summer and used as shelter against sun, Wild pigs being reluctant to come out during the day.

Woodland and dry wetland habitats were used in proportion to their availability. Mature woodlands are mostly preferred by Wild pigs (Leaper *et al.* 1999); wetlands provide high quality habitats for wild pig population because they provide shelter and a wide variety of food resources (Massei *et al.* 1996). But, the comparatively lower preference and least HPI values in all the months could be attributed to a high intensity of disturbance (D'Andea et al. 1995; Maillard and Fournier 1995; DEFRA 2005) and water scarcity in the wetlands due to dry conditions. The avoided habitats were tall grassland savannah and *Prosopis juliflora* thickets. Habitat use by Wild pigs is determined by food availability, shelter, weather conditions and human disturbance (Kurtz and Marchinton 1972; Meriggi and Sacchi 1992; Boitani *et al.* 1994). The available grass species in the grassland, i.e., *Viteveria zizanioides* and *Desmostachya bipinnata* being coarse, old and almost unpalatable were accompanied by low cover due to low shrub density. Therefore, these alongwith the extent of disturbance in the two habitat types might be attributed for the avoidance.

The positive correlations of Wild pig density with grass variables supports the fact that it is primarily a herbivore and depends on grass and other tuberous species (Henry and Conley 1972; Baber and Coblentz 1987; Schley and Roper 2003). Also during dry season, wild pigs are known to prefer *Cyanodon* bottoms because of their physiological need for free water and behavioural responses to high temperature (Baber and Coblentz 1986). The significant positive correlation between pellet group densities of Wild pig and Chital, Nilgai and Hare indicate a positive interaction among these species. Shared resources sometimes facilitate coexistence of different ungulate species in a community (Bagchi *et al.* 2003). Highly significant negative correlation with various tree attributes was clearly because of poor forage availability, low cover and high disturbance. Distance from water source showed highly significant negative correlation with Wild pig pellet group density, thus confirming that water source plays a vital role in the selection of a suitable habitat. The availability of water is unlikely to be a limiting factor in some areas (Leaper *et al.* 1999).

The study demonstrates a consistent growth in the wild pig population in the National Park together with the factors including food availability, shelter, human disturbance and water availability playing a major role in the habitat utilization patterns of the animal. However, the growing population also solicits for an apparent increase in the availability of the food resources. Therefore, the existing habitats, especially grasslands should be managed efficiently to avoid the human-animal conflict with the surrounding areas.

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